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ORIGINAL PAPER

Forage quality and mineral composition of common grasspea (*Lathyrus sativus* L.) genotypes*

Mehmet Arif Özyazıcı, Semih Açıkbaş

Department of Field Crops
Siirt University, Siirt, Türkiye

Abstract

This study was performed to determine some forage quality properties and macronutrient content of common grasspea (*Lathyrus sativus* L.) genotypes under semi-arid climatic conditions. Twenty-four different common grasspea genotypes, 22 lines, and 2 registered cultivars were used as plant material. In the study, a field experiment was established according to a randomized block experimental design with 3 replications under the ecological conditions of Siirt province in the Southeastern Anatolia Region of Türkiye in 2016 and 2017. The study investigated the acid detergent fiber (ADF) ratio, neutral detergent fiber (NDF) ratio, crude protein (CP) ratio, relative feed value (RFV), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) properties. Furthermore, the Ca/P and K/(Ca+Mg) ratios, which are important for the health of animals, were also found. According to the averages of the two-year research results, the ADF ratio was determined to vary between 28.92-33.44%, the NDF ratio between 35.13-40.47%, the CP ratio between 22.30-25.78%, RFV between 146.75-176.80, P between 0.393-0.427%, K between 2.13-2.46%, Ca between 1.267-1.378%, and Mg between 0.230-0.257%. The Ca/P and K/(Ca+Mg) ratios changed between 3.14-3.48 and 0.720-0.918, respectively. According to the research results, the common grasspea genotypes grown under semi-arid climatic conditions produced feed of "very good-top quality" standards. It was revealed that most genotypes examined in the study were sufficient to meet the needs of ruminates in terms of P, K, Ca, and Mg. However, some genotypes were insufficient, especially in terms of Mg.

Keywords: *Lathyrus sativus* L., crude protein, relative feed value, phosphorus, potassium, calcium, magnesium, grass tetany

Mehmet Arif Özyazıcı, Assoc. Prof. Dr., Department of Field Crops, Faculty of Agriculture, Siirt University, Siirt, Türkiye, e-mail: arifozyazici@siirt.edu.tr

***** The first-year data of some parameters in this study were presented as an oral presentation at the "International Conference on Agriculture, Forest, Food, Veterinary Sciences and Technologies" congress held in Çeşme-İzmir-Türkiye on April 02-05, 2018, and the abstract text was published in the mentioned congress proceedings book.

INTRODUCTION

In animal nutrition, meadow rangelands and forage crop areas in field agriculture are known as the main sources of quality roughage. Nowadays, rangelands are under the influence of such factors as the population increase, economic growth, expansion of agriculture, and concentration in livestock. Under this influence, the desired amount of herbage cannot be obtained in meadow rangelands due to climate change, global warming, and incorrect management practices. The second important source of roughage, the agriculture of forage crops, is not at the desired level in field agriculture, in terms of the share of crop cultivation, which is another reason for the lack of quality roughage in animal production. It is possible to increase the cultivation of forage crops by developing forage crop species and cultivars suitable for different ecologies and/or revealing both the yield and quality characteristics of the existing cultivars by determining their adaptability in different ecologies. This is also important for obtaining quality animal products and presenting these products to people in today's world, where food safety is under threat.

In world agriculture, various forage crop species and cultivars are grown depending on different product patterns according to different ecologies in many areas. Additionally, concentrating on certain species in forage crop cultivation within the crop patterns maintained in countries restricts crop diversity and prevents the spread of alternative species. The common grasspea (*Lathyrus sativus* L.) plant has a highly versatile potential for use; it is used as green herbage, hay, and grain feed in animal nutrition, as a green manure plant in improving the soil structure, and in human nutrition. *L. sativus* (Vaz Patto et al. 2006, Özyazıcı, Açıkbaş 2019), which is successfully grown in areas where other legumes do not provide sufficient yield and drought problems are experienced, is tolerant to salt stress and resistant to periodic flooding, and can be grown in very poor and heavy clay soils (Jiang et al. 2013, Tokarz et al. 2021). The plant is also rich in protein and essential amino acids, and contains 18.2-34.6% protein, 6.69% albumin, 1.5% prolamin, 13.3% globulin, and 3.8% glutelin (Urga et al. 2005, Kumar et al. 2013, Lambein et al. 2019). When these important agricultural advantages are combined with the structural feed quality properties in their composition, which creates its nutritional value, common grasspea can be one of the main sustainable agricultural products in the future.

The nutritional value of a forage crop is an indicator of the feed quality, and the chemical composition of plants (such as crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and minerals) is among the main criteria of the nutritional value of a forage crop. The chemical composition of feeds varies significantly according to the forage crop species and cultivar, in addition to such factors as intercropping of forage crops, plant developmental stage and cutting time, some physical and chemical properties of soils, fertilization, and climate (Markovic et al. 2014, Özyazıcı, Açıkbaş 2020).

The current study was conducted to determine the nutritional value and macronutrient content of common grasspea (*L. sativus* L.) genotypes grown in the semi-arid climate zone.

MATERIALS AND METHODS

The field experiment in the research was carried out under the ecological conditions of Siirt province in the Southeastern Anatolia Region of Türkiye (Figure 1) in 2016-2017.

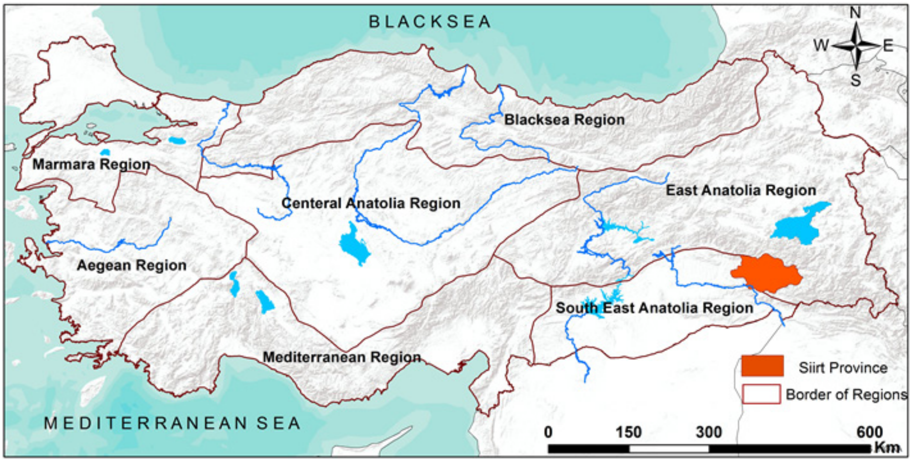

Fig. 1. Study area location map

According to long-term (1970-2017) meteorological data (Anonymous 2017) of Siirt province, the current climate in the region is semi-arid. Whereas the long-term average temperature in the research region is 16.2°C, the average temperature values in the research years (2016 and 2017) were 17.1°C and 17.2°C, respectively. The total precipitation amounts in the experiment years were 775.0 mm and 552.0 mm, respectively, and the long-term average total precipitation is 647.0 mm (Figure 2).

The soils of the experiment site established every two years in the research are salt-free, slightly alkaline, calcareous-medium calcareous in terms of the lime content, adequate in terms of available potassium (K) content, and good in terms of available calcium (Ca) and magnesium (Mg) contents. Soils in the first year had clayey texture, low organic matter content, and very low available phosphorus (P) content; soils in the second year had clayey-loam texture, moderate organic matter and available P content (Table 1).

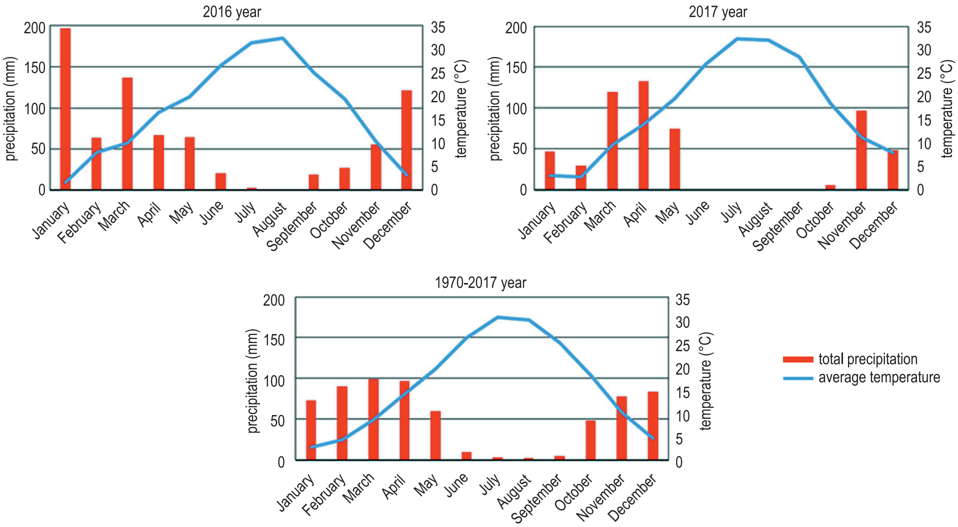

Fig. 2. Some climate data of the study area

Table 1

Some physical and chemical properties of the soils in the research site (0-20 cm)

Soil property	Value	
	2016 experimental site	2017 experimental site
Sand (%)	14.00	39.84
Clay (%)	58.00	34.16
Silt (%)	28.00	26.00
pH	7.95	7.53
Electrical conductivity (dS m^{-1})	0.107	0.150
Lime ($CaCO_3$) (%)	10.5	4.2
Organic matter (%)	1.35	2.22
Available P (kg P_2O_5 ha^{-1})	23	79
Available K (kg K_2O ha^{-1})	1630	1170
Available Ca (ppm)	15142	3983
Available Mg (ppm)	1568	370

In the study, a total of 24 common grasspea (*L. sativus* L.) genotypes, 22 lines obtained from ICARDA (International Center for Agricultural Research in the Dry Areas), and 2 cultivars (GAP Mavisi and Gürbüz-2001) bred in Türkiye, were used as plant material.

The field experiments in the research were established according to a randomized block design with 3 replications. Sowing was performed in 6 rows in each plot, with a 25 cm row spacing and a 140 kg ha^{-1} sowing norm. According to the soil analysis results (Table 1), with homogeneous sowing in each plot, urea fertilizer 46% nitrogen (N) was applied as 40 kg ha^{-1} of pure N in the first year and 30 kg ha^{-1} of pure N in the second year, and triple super phosphate (43-44% P) fertilizer was applied as 60 kg P_2O_5 ha^{-1} of pure P in the first year. Phosphorus fertilizer was not applied in the second year of the research since available P in the soil was sufficient (Table 1).

Sowing was performed on 03.03.2016 in the first year and on 14.03.2017 in the second year. Harvesting was carried out during the full flowering period (on 15.05.2016 in the first year and on 25.05.2017 in the second year).

Plant samples weighing 500 g were taken from each harvested plot, and after the samples were air-dried for a certain time, they were dried in an oven set at 70°C for 48 h, ground and made ready for analysis. CP, ADF, NDF, total P, K, Ca, and Mg ratios were determined in the ground hay samples using an #IC-0904FE calibration set (Anonymous 2018) and a NIRS (Near Infrared Reflectance Spectroscopy) device (Brogna et al. 2009). The study also found the Ca/P and K/(Ca+Mg) ratios in the samples. The relative feed value (RFV) of common grasspea hay was determined according to the guidelines reported by Van Dyke, Anderson (2000).

In the study, the values expressed as a percentage (%) were analyzed statistically after the angle transformation. The data obtained from the study were subjected to analysis of variance according to the randomized blocks experimental design, and according to the results of the F test, differences between the groups were determined with theTukey's multiple comparison test (Açıkgöz, Açıkgöz 2001).

RESULTS AND DISCUSSION

Forage quality

The ADF and NDF ratios of feeds are among the important indicators of forage quality. Table 2 contains the ADF and NDF ratios determined in the hay of different common grasspea genotypes. According to the average of two years, while the highest ADF and NDF ratios in the dry matter were determined in the GAP Mavisi cultivar with 33.44% and 40.47%, respectively, the lowest ADF ratio was in Sel 1837 with 28.92%, and the NDF ratio was 35.13% in Sel 706 genotypes. This difference between genotypes in terms of ADF and NDF ratios was found to be significant (p<0.01) – Table 2. It is thought that the genotypic characteristics of the materials used affect these differences between the genotypes. Studies conducted on common grasspea have reported that the ADF ratio of hay varies between 20.2-39.0% and the NDF ratio varies between 28.8-51.2% (Başaran et al. 2011, Karadağ et al. 2011, Sabancı et al. 2016, Deniz et al. 2020). It was seen that the ADF and NDF values determined in our study were within this range of variation, reported in the literature.

Table 2

The ADF and NDF ratios determined in common grasspea genotypes (%)*

Genotypes	ADF			NDF		
	2016	2017	mean	2016	2017	mean
IFLS 349	28.93 *e-h*	34.78 *a-d*	31.86 *AB*	36.56	42.11	39.34 *AB*
IFLS 257	27.10 *hı*	36.03 *a-d*	31.57 *A-D*	35.50	42.13	38.82 *ABC*
IFLS 298	24.41 *ı*	36.93 *ab*	30.67 *BCD*	31.81	42.58	37.20 *ABC*
IFLS 206	27.15 *hı*	33.16 *b-e*	30.16 *BCD*	34.04	40.59	37.32 *ABC*
GAP Mavisi	28.51 *fı*	38.38 *a*	33.44 *A*	37.14	43.79	40.47 *A*
IFLS 968	25.67 *hı*	36.84 *abc*	31.26 *A-D*	32.90	44.06	38.48 *ABC*
Gürbüz-2001	27.88 *g-ı*	34.67 *a-d*	31.27 *A-D*	35.54	41.32	38.43 *ABC*
Sel 666	27.67 *g-ı*	36.40 *abc*	32.04 *AB*	34.63	41.96	38.30 *ABC*
Sel 668	26.14 *hı*	34.76 *a-d*	30.45 *BCD*	31.56	39.86	35.71 *BC*
Sel 676	26.25 *hı*	34.75 *a-d*	30.50 *BCD*	34.87	41.27	38.07 *ABC*
Sel 681	27.26 *hı*	35.17 *a-d*	31.21 *A-D*	34.33	42.10	38.21 *ABC*
Sel 702	25.53 *hı*	32.67 *c-f*	29.10 *CD*	31.97	39.50	35.74 *BC*
Sel 706	26.22 *hı*	31.89 *d-g*	29.06 *CD*	32.98	37.28	35.13 *C*
Sel 299	27.71 *g-ı*	34.34 *a-d*	31.03 *A-D*	35.25	39.71	37.48 *ABC*
Sel 1837	24.89 *hı*	32.94 *b-e*	28.92 *D*	32.56	40.15	36.36 *BC*
Sel 2267	26.57 *hı*	36.24 *abc*	31.40 *A-D*	34.37	41.91	38.14 *ABC*
Sel 2273	25.76 *hı*	34.37 *a-d*	30.07 *BCD*	33.57	42.45	38.01 *ABC*
Sel 2329	26.84 *hı*	36.68 *abc*	31.76 *A-C*	34.10	42.05	38.07 *ABC*
Sel 385	26.53 *hı*	36.06 *a-d*	31.30 *A-D*	33.71	41.25	37.48 *ABC*
Sel 421	26.86 *hı*	33.37 *bcd*	30.11 *BCD*	34.66	41.43	38.05 *ABC*
Sel 440	26.96 *hı*	32.91 *b-e*	29.93 *BCD*	35.58	40.31	37.95 *ABC*
Sel 1794	25.39 *hı*	33.95 *bcd*	29.67 *BCD*	33.16	40.35	36.76 *ABC*
ETH-24	26.19 *hı*	35.10 *a-d*	30.65 *BCD*	34.05	41.36	37.71 *ABC*
ETH WIR-70	28.18 *g-ı*	33.78 *bcd*	30.98 *A-D*	35.02	39.23	37.12 *ABC*
Mean	26.69 *B*	34.84 *A*		34.16 *B*	41.20 *A*	
P value						
Year (Y)	0.0001			0.0001		
Genotype (G)	0.0001			0.0012		
GxY	0.0001			0.1515		
CV (%)	4.12			4.88		

* The difference between the means shown with the same letter in the same group and in the same column is not statistically significant. *P* – level of significance, CV – coefficient of variation

The ADF ratio, which refers to the structural carbohydrates of plants and concerns cellulose and lignin (Carlier et al. 2009), is an indicator of total digestible nutrients in roughage (Gürsoy, Macit 2014); whereas the NDF ratio (Skamarokhova et al. 2020, Widiarsih et al. 2021), which is the most important structural component of the plant cell wall and refers to cellulose, hemicellulose and lignin, is an indicator of ruminant feed consumption (Lemaire, Belanger 2019). It is desirable that the ADF and NDF ratios, among the important criteria of the nutritional value of roughage, are low in the feeds. When the ADF and NDF of the herbage from common grasspea genotypes were evaluated considering the forage equality standard reported by Rohweder et al. (1978) (<31% – top quality, 31-35% – very good, 36-40% – good, 41-42% – medium, 43-45% – bad and >45% – unacceptable for ADF; <40% – top quality, 40-46% – very good, 47-53% – good, 54-60% – medium, 61-65% – bad and >65% – unacceptable for NDF), it was revealed that the genotypes produced feed of varying quality within very good-top quality standards.

The study also found significant ($p<0.01$) differences between the years in terms of the ADF and NDF ratios. While the mean ADF ratio in the first year was 26.69% and the mean NDF ratio in the first year was 34.16%, these values in the second year were 34.84% and 41.20%, respectively (Table 2). It is thought that precipitation and temperature changes caused this difference between the years. On the other hand, the fact that the ADF ratios of some genotypes had different values over the years due to differences in climate and soil characteristics caused the year x genotype interaction to be statistically very significant ($p<0.01$) in terms of ADF (Table 2).

Crude protein is one of the most valuable components of animal feed. A statistically significant difference at the p<0.01 level was revealed between the genotypes and years in terms of CP ratios. The difference between years can be explained by the variation in precipitation and temperature by years. According to the average of two years, the highest CP ratio was found in the Sel 702 (25.78%) genotype. The lowest CP ratio was detected in the IFLS 257 genotype (22.30%) – Table 3. It is considered that this difference between the genotypes in the CP ratio was caused by their genetic structures. Some studies (Sabancı et al. 2016, Deniz et al. 2020) have also reported a significant difference between *L. sativus* genotypes in terms of the CP ratio. In the review of studies conducted with common grasspea, it was stated that the CP ratios of different genotypes varied between 21.45-23.45% in the study by Ramachandran et al. (2005), between 19.30-21.20% in the study by Larbi et al. (2010), between 10.12-10.96% in the study by Kosev, Vasileva (2018), between 19.05-29.23% in the study by Sabancı et al. (2016), and between 11.90-20.23% in the study by Deniz et al. (2020). The reason for the differences between these values reported in the literature and the findings of our study can be explained by differences in the genotypes used, the locations where the studies were performed as well as the agricultural practices applied.

The CP content of roughage is one of the parameters used to characterize forage quality (Hu et al. 2021). Hence, the protein ratio of roughage in feed rations is important in animal nutrition. Meen (2001) emphasized that the CP content in feed rations must be at least 7% to meet the needs of ruminants in general. Considering the limit values reported by Rohweder et al. (1978) (<19% – top quality, 17-19% – very good, 14-16% – good, 11-13% – medium, 8-10% – bad, and >8% – unacceptable), the CP ratio values identified in the common grasspea genotypes were in the top quality class. Therefore, it can be said that the examined common grasspea genotypes were able to meet the protein needs of animals in their rations, and could be characterized by a high protein content for animal feed.

RFV, acquired from ADF and NDF values, is an index expressing the digestibility and consumption potential of feed (Stokes, Prostko 1998). Considering the RFV values in Table 3, the highest RFV values of 176.80, 175.13, and 173.45 were detected in Sel 706, Sel 702, and Sel 668 genotypes, respectively, which were in the same group statistically. The lowest RFV value was determined in the GAP Mavisi cultivar with 146.75, and there was a statistically significant difference ($p<0.05$) between the GAP Mavisi cultivar and other genotypes (Table 3). The variability of the genotypes in terms of ADF and NDF ratios was naturally reflected in the RFV results.

Statistically very significant ($p<0.01$) variability was also observed between the years; while the mean RFV value of the common grasspea genotypes obtained in the first year was 186.58, this value was determined as 139.74 in the second year (Table 3). This difference between the years in terms of RFV calculated using the NDF and ADF values of feed can be explained by the variability of climatic factors.

The RFV index classification developed for the quality control of the alfalfa plant in the United States of America (>151 – top quality, 151-125 – very good, 124-103 – good, 102-87 – medium, 86-75 – bad, and <75 – unacceptable; Rohweder et al. 1978) is an important guide used for all forage crops in the marketing and quality determination of roughage nowadays. According to the mentioned classification, it is understood that the RFV of the hay belonging to the common grasspea genotypes is within very good-top quality standards.

Forage macronutrient content

Table 4 presents the P and K ratios determined in the dry matter of the common grasspea genotypes, and Table 5 presents the Ca and Mg ratios. As a result of the analysis of variance applied to the two-year data, statistically significant differences at the $p<0.05$ level were revealed between the genotypes examined in the study in terms of the P ratio. The highest P ratio was found in Sel 702 (0.427%) and Sel 706 (0.427%) genotypes, which constituted the first group statistically; these were followed by ETH WIR-70 (0.425%), Sel 668 (0.417%), IFLS 257 (0.415%), Sel 676 (0.415%), Sel 299 (0.415%), Sel 1837 (0.415%), Sel 681 (0.412%), IFLS 206 (0.410%), and Sel 666 (0.408%) genotypes. The lowest P ratio was identified in the GAP Mavisi cultivar with 0.393% (Table 4).

Table 3

The CP ratio (%) and RFV determined in common grasspea genotypes*

Genotypes	CP			RFV		
	2016	2017	mean	2016	2017	mean
IFLS 349	22.01	24.47	23.24 *BCD*	168.89	136.58	152.73 *AB*
IFLS 257	20.99	23.61	22.30 *D*	179.65	134.42	157.04 *AB*
IFLS 298	21.80	24.50	23.15 *BCD*	209.00	131.35	170.18 *AB*
IFLS 206	23.80	25.49	24.65 *ABC*	185.71	144.49	165.10 *AB*
GAP Mavisi	21.61	24.74	23.18 *BCD*	168.13	125.36	146.75 *B*
IFLS 968	23.24	24.66	23.95 *A-D*	196.32	127.09	161.71 *AB*
Gürbüz-2001	22.24	25.43	23.83 *A-D*	176.48	139.37	157.93 *AB*
Sel 666	22.04	24.45	23.25 *BCD*	182.00	134.25	158.12 *AB*
Sel 668	21.70	23.62	22.66 *BCD*	202.61	144.28	173.45 *A*
Sel 676	22.64	25.16	23.90 *A-D*	183.13	139.34	161.24 *AB*
Sel 681	23.64	24.54	24.09 *A-D*	184.23	135.93	160.08 *AB*
Sel 702	25.23	26.33	25.78 *A*	200.87	149.39	175.13 *A*
Sel 706	23.58	25.54	24.56 *ABC*	193.53	160.07	176.80 *A*
Sel 299	22.65	24.53	23.59 *A-D*	178.36	145.61	161.99 *AB*
Sel 1837	21.45	23.38	22.42 *CD*	199.06	146.48	172.77 *AB*
Sel 2267	21.56	23.80	22.68 *BCD*	184.60	134.67	159.63 *AB*
Sel 2273	22.28	24.55	23.41 *BCD*	190.70	136.18	163.44 *AB*
Sel 2329	22.14	23.79	22.97 *BCD*	185.72	133.44	159.58 *AB*
Sel 385	22.06	23.86	22.96 *BCD*	188.48	137.13	162.81 *AB*
Sel 421	22.72	25.48	24.10 *A-D*	182.85	141.30	162.07 *AB*
Sel 440	22.55	25.35	23.95 *A-D*	178.00	146.00	162.00 *AB*
Sel 1794	22.67	25.20	23.94 *A-D*	193.85	144.06	168.95 *AB*
ETH-24	23.47	24.71	24.09 *A-D*	187.44	138.52	162.98 *AB*
ETH WIR-70	23.00	26.53	24.77 *AB*	178.39	148.40	163.39 *AB*
Mean	22.55 *B*	24.74 *A*		186.58 *A*	139.74 *B*	
P value						
Year (Y)	0.0009			0.0001		
Genotype (G)	0.0001			0.0105		
GxY	0.8858			0.1559		
CV (%)	4.36			7.42		

* The difference between the means shown with the same letter in the same group and in the same column is not statistically significant. *P* – level of significance, CV – coefficient of variation

Concerning the variation of the genotypes in terms of potassium, the highest values were determined in Sel 706 (2.44%), Sel 1837 (2.44%), ETH-24 (2.44%), and ETH WIR-70 (2.46%) genotypes, while the lowest value

Table 4

The P and K ratios determined in common grasspea genotypes (%)*

Genotypes	P			K		
	2016	2017	mean	2016	2017	mean
IFLS 349	0.41	0.40	0.403 *CDE*	3.02 *a*	1.64 *bc*	2.33 *ABC*
IFLS 257	0.44	0.39	0.415 *A-D*	3.15 *a*	1.26 *de*	2.21 *BC*
IFLS 298	0.43	0.38	0.405 *CDE*	3.09 *a*	1.63 *bc*	2.36 *AB*
IFLS 206	0.44	0.38	0.410 *A-E*	3.15 *a*	1.34 *b-e*	2.25 *ABC*
GAP Mavisi	0.41	0.37	0.393 *E*	3.02 *a*	1.23 *e*	2.13 *C*
IFLS 968	0.44	0.36	0.397 *DE*	3.08 *a*	1.33 *cde*	2.20 *BC*
Gürbüz-2001	0.43	0.38	0.405 *CDE*	3.18 *a*	1.48 *b-e*	2.33 *ABC*
Sel 666	0.43	0.38	0.408 *A-E*	3.22 *a*	1.37 *b-e*	2.30 *ABC*
Sel 668	0.44	0.40	0.417 *ABC*	3.22 *a*	1.60 *bcd*	2.41 *AB*
Sel 676	0.44	0.39	0.415 *A-D*	3.25 *a*	1.36 *b-e*	2.30 *ABC*
Sel 681	0.45	0.38	0.412 *A-E*	3.32 *a*	1.46 *b-e*	2.39 *AB*
Sel 702	0.45	0.40	0.427 *A*	3.19 *a*	1.63 *bc*	2.41 *AB*
Sel 706	0.44	0.41	0.427 *A*	3.19 *a*	1.68 *b*	2.44 *A*
Sel 299	0.43	0.40	0.415 *A-D*	3.12 *a*	1.60 *bcd*	2.36 *AB*
Sel 1837	0.43	0.40	0.415 *A-D*	3.25 *a*	1.64 *bc*	2.44 *A*
Sel 2267	0.42	0.38	0.400 *CDE*	3.19 *a*	1.53 *b-e*	2.36 *AB*
Sel 2273	0.41	0.38	0.397 *DE*	3.04 *a*	1.55 *b-e*	2.29 *ABC*
Sel 2329	0.42	0.39	0.407 *B-E*	3.16 *a*	1.48 *b-e*	2.32 *ABC*
Sel 385	0.41	0.40	0.407 *B-E*	3.06 *a*	1.49 *b-e*	2.28 *ABC*
Sel 421	0.43	0.38	0.405 *CDE*	3.23 *a*	1.48 *b-e*	2.35 *AB*
Sel 440	0.43	0.38	0.403 *CDE*	3.27 *a*	1.45 *b-e*	2.36 *AB*
Sel 1794	0.41	0.40	0.407 *B-E*	3.06 *a*	1.50 *b-e*	2.28 *ABC*
ETH-24	0.44	0.38	0.407 *B-E*	3.30 *a*	1.58 *bcd*	2.44 *A*
ETH WIR-70	0.44	0.41	0.425 *AB*	3.25 *a*	1.67 *bc*	2.46 *A*
Mean	0.43 *A*	0.39 *B*		3.17 *A*	1.50 *B*	
P value						
Year (Y)	0.0004			0.0001		
Genotype (G)	0.0191			0.0001		
GxY	0.0511			0.0001		
CV (%)	3.93			4.46		

* The difference between the means shown with the same letter in the same group and in the same column is not statistically significant. *P* – level of significance, CV – coefficient of variation

was found in the GAP Mavisi cultivar with 2.13%. There was a statistically significant ($p<0.01$) difference between the GAP Mavisi, IFLS 257, and IFLS 968 genotypes and the other genotypes (Table 4).

According to the average data of two years, there were significant differences in terms of Ca (p<0.01) and Mg (p<0.05) ratios between the common grasspea genotypes examined in the study. Whereas Sel 702 (1.378%) was the genotype with the highest Ca value, the genotype with the lowest value was Sel 440 (1.267%). Concerning Mg ratios, the highest value of 0.257% was determined in IFLS 968 and Sel 668 genotypes, constituting the first group statistically, and the difference between the other genotypes was statistically insignificant, except for the IFLS 257 genotype (Table 5).

Many studies conducted with different plant species in different ecologies (Lema et al. 2004, Markovic et al. 2014, Özyazıcı et al. 2018, Ozyazici, Acikbas 2019) have reported that the P, K, Ca, and Mg content in roughage varies significantly between cultivars and/or genotypes of the same species. Başaran et al. (2011) reported that the P, K, Ca, and Mg content in the dry matter of common grasspea hay varied between 0.34-0.40%, 1.67-2.33%, 1.42-1.69%, and 0.26-0.35%, respectively, while Yolcu et al. (2009) determined these values as 0.25%, 1.12%, 0.7%, and 0.25%.

To meet the macroelement needs of animals at a minimum level in feed rations, Muller (2009) reported that there must be 0.40% P, 1.00% K, and 0.90% Ca in feeds, and Anonymous (2001) stated that there must be 0.25% Mg. According to these criteria in the literature, based on the two-year average values, it is understood that all genotypes, except for GAP Mavisi, in terms of P and all genotypes in terms of K and Ca meet the needs of ruminates. Upon examining the genotypes concerning Mg, it can be said that the Mg contents of the other genotypes, except for IFLS 349, IFLS 257, IFLS 206, Sel 666, Sel 676, Sel 1837, Sel 2267, and ETH WIR-70 genotypes, were sufficient.

Significant (p<0.01) variability was also observed between the years in terms of the P, K, Ca, and Mg contents of the genotypes examined in the study (Tables 4 and 5). This difference in optimum fertilization conditions can be explained by the fact that other physical and chemical fractions of the soil and climatic conditions, such as temperature, sunshine duration, and precipitation amount, affect the concentration of mineral substances in the plant.

Furthermore, the study found the year x genotype interaction significant in terms of K (p<0.01) and Ca (p<0.05) contents (Tables 4 and 5). While the K content of all genotypes was statistically the highest and in the same group in the first year, many genotypes were in the lower groups in the second year (Table 4). This resulted in the interaction being significant in terms of K. Upon examining the year x cultivar interaction in terms of Ca (Table 5), the highest Ca ratio was found in the Gürbüz 2001 (1.383%) cultivar in the first year, whereas the highest Ca ratio was detected in Sel 681 (1.400%) genotype in the second year. The reason for the interaction in terms of Ca being significant is that some genotypes showed different values in different years.

Table 5

The Ca and Mg ratios determined in common grasspea genotypes (%)*

Genotypes	Ca			Mg		
	2016	2017	mean	2016	2017	mean
IFLS 349	1.333 *a-ı*	1.320 *a-ı*	1.327 *A-F*	0.23	0.25	0.240 *AB*
IFLS 257	1.350 *a-g*	1.363 *a-e*	1.356 *ABC*	0.22	0.24	0.230 *B*
IFLS 298	1.323 *a-ı*	1.353 *a-f*	1.338 *A-E*	0.23	0.26	0.248 *AB*
IFLS 206	1.287 *d-ı*	1.360 *a-e*	1.323 *A-G*	0.22	0.25	0.237 *AB*
GAP Mavisi	1.290 *c-ı*	1.373 *a-d*	1.332 *A-E*	0.23	0.27	0.247 *AB*
IFLS 968	1.370 *a-d*	1.367 *a-d*	1.368 *AB*	0.24	0.27	0.257 *A*
Gürbüz-2001	1.383 *ab*	1.363 *a-e*	1.373 *AB*	0.24	0.26	0.247 *AB*
Sel 666	1.250 *hı*	1.310 *a-ı*	1.280 *EFG*	0.22	0.26	0.242 *AB*
Sel 668	1.357 *a-f*	1.353 *a-f*	1.355 *ABC*	0.25	0.27	0.257 *A*
Sel 676	1.303 *b-ı*	1.293 *b-ı*	1.298 *C-G*	0.22	0.27	0.243 *AB*
Sel 681	1.353 *a-f*	1.400 *a*	1.377 *AB*	0.24	0.26	0.248 *AB*
Sel 702	1.380 *abc*	1.377 *a-d*	1.378 *A*	0.25	0.26	0.253 *AB*
Sel 706	1.340 *a-h*	1.357 *a-f*	1.348 *A-D*	0.25	0.26	0.255 *AB*
Sel 299	1.337 *a-ı*	1.327 *a-ı*	1.332 *A-E*	0.23	0.26	0.248 *AB*
Sel 1837	1.327 *a-ı*	1.333 *a-ı*	1.330 *A-E*	0.23	0.26	0.242 *AB*
Sel 2267	1.267 *f-ı*	1.313 *a-ı*	1.290 *D-G*	0.23	0.26	0.243 *AB*
Sel 2273	1.340 *a-h*	1.363 *a-e*	1.351 *ABC*	0.23	0.26	0.248 *AB*
Sel 2329	1.330 *a-ı*	1.357 *a-f*	1.343 *A-D*	0.23	0.28	0.255 *AB*
Sel 385	1.313 *a-ı*	1.330 *a-ı*	1.322 *A-G*	0.24	0.27	0.255 *AB*
Sel 421	1.247 *ı*	1.290 *c-ı*	1.268 *FG*	0.22	0.27	0.247 *AB*
Sel 440	1.260 *ghı*	1.273 *e-ı*	1.267 *G*	0.22	0.27	0.245 *AB*
Sel 1794	1.357 *a-f*	1.317 *a-ı*	1.337 *A-E*	0.23	0.27	0.250 *AB*
ETH-24	1.300 *b-ı*	1.337 *a-ı*	1.318 *B-G*	0.24	0.26	0.247 *AB*
ETH WIR-70	1.320 *a-ı*	1.353 *a-f*	1.337 *A-E*	0.24	0.24	0.240 *AB*
Mean	1.32 *B*	1.34 *A*		0.23 *B*	0.26 *A*	
P value						
Year (Y)	0.0029			0.0003		
Genotype (G)	0.0001			0.0277		
GxY	0.0267			0.1160		
CV (%)	2.03			4.93		

* The difference between the means shown with the same letter in the same group and in the same column is not statistically significant. *P* – level of significance, CV – coefficient of variation

In animal nutrition, the ratio between some nutrients is as important as the mineral substances in the feed content. In this sense, especially Ca/P and K/(Ca+Mg) ratios are evaluated in terms of metabolic activities and the health of animals. Table 6 contains the Ca/P and K/(Ca+Mg) ratios of com-

Table 6

The Ca/P and K/(Ca+Mg) ratios determined in common grasspea genotypes*

Genotypes	Ca/P			K/(Ca+Mg)		
	2016	2017	mean	2016	2017	mean
IFLS 349	3.26 *c-m*	3.33 *b-l*	3.29 *ABC*	0.523 *k*	0.957 *j*	0.740 *E-I*
IFLS 257	3.09 *g-m*	3.47 *a-h*	3.28 *ABC*	0.497 *k*	1.270 *ab*	0.883 *AB*
IFLS 298	3.11 *g-m*	3.53 *a-g*	3.32 *ABC*	0.500 *k*	0.993 *g-j*	0.747 *D-I*
IFLS 206	2.95 *klm*	3.55 *a-f*	3.25 *ABC*	0.477 *k*	1.203 *bc*	0.840 *BC*
GAP Mavisi	3.13 *e-m*	3.68 *abc*	3.40 *ABC*	0.503 *k*	1.333 *a*	0.918 *A*
IFLS 968	3.14 *e-m*	3.84 *a*	3.48 *A*	0.523 *k*	1.237 *abc*	0.880 *AB*
Gürbüz-2001	3.25 *c-m*	3.56 *a-e*	3.40 *ABC*	0.510 *k*	1.093 *def*	0.802 *CDE*
Sel 666	2.89 *m*	3.42 *a-j*	3.15 *BC*	0.457 *k*	1.150 *cd*	0.803 *CDE*
Sel 668	3.12 *f-m*	3.42 *a-j*	3.27 *ABC*	0.497 *k*	1.013 *e-j*	0.755 *D-I*
Sel 676	2.98 *j-m*	3.29 *b-m*	3.14 *C*	0.470 *k*	1.150 *cd*	0.810 *CD*
Sel 681	3.03 *h-m*	3.72 *ab*	3.37 *ABC*	0.480 *k*	1.140 *cd*	0.810 *CD*
Sel 702	3.05 *h-m*	3.45 *a-h*	3.25 *ABC*	0.513 *k*	1.000 *f-j*	0.757 *D-I*
Sel 706	3.05 *h-m*	3.28 *b-m*	3.17 *BC*	0.500 *k*	0.963 ıj	0.732 *GHI*
Sel 299	3.14 *e-m*	3.29 *b-m*	3.21 *ABC*	0.503 *k*	0.993 *g-j*	0.748 *D-I*
Sel 1837	3.09 *g-m*	3.34 *b-l*	3.22 *ABC*	0.480 *k*	0.970 *hıj*	0.725 *HI*
Sel 2267	3.05 *h-m*	3.43 *a-ı*	3.24 *ABC*	0.467 *k*	1.030 *e-j*	0.748 *D-I*
Sel 2273	3.25 *c-m*	3.59 *a-d*	3.42 *AB*	0.520 *k*	1.053 *d-j*	0.787 *C-H*
Sel 2329	3.17 *d-m*	3.45 *a-h*	3.31 *ABC*	0.493 *k*	1.103 *de*	0.798 *C-F*
Sel 385	3.18 *d-m*	3.32 *b-m*	3.25 *ABC*	0.510 *k*	1.073 *d-g*	0.792 *C-G*
Sel 421	2.92 *lm*	3.37 *b-k*	3.15 *BC*	0.457 *k*	1.053 *d-j*	0.755 *D-I*
Sel 440	2.96 *klm*	3.35 *b-l*	3.15 *BC*	0.453 *k*	1.063 *d-h*	0.758 *D-I*
Sel 1794	3.28 *b-m*	3.30 *b-m*	3.29 *ABC*	0.520 *k*	1.057 *d-ı*	0.788 *C-H*
ETH-24	2.97 *klm*	3.55 *a-f*	3.27 *ABC*	0.467 *k*	1.007 *e-j*	0.737 *F-I*
ETH WIR-70	3.01 *ı-m*	3.30 *b-m*	3.16 *BC*	0.480 *k*	0.960 ıj	0.720 *I*
Mean	3.08 *B*	3.45 *A*		0.492 *B*	1.078 *A*	
P value						
Year (Y)	0.0001			0.0001		
Genotype (G)	0.0001			0.0001		
GxY	0.0002			0.0001		
CV (%)	3.98			3.78		

* The difference between the means shown with the same letter in the same group and in the same column is not statistically significant. *P* – level of significance, CV – coefficient of variation

mon grasspea genotypes. Significant (p<0.01) differences were revealed between the examined genotypes in terms of the Ca/P ratio. The Ca/P ratio of the genotypes varied between 3.14-3.48 (Table 6). It is usually recommended that the Ca/P ratio in feed rations be between 1:1 and 2:1 (National Academy of Sciences 1984). It is reported to cause milk fever in excess in animals (Açıkgöz 2001). Considering this limit value, it was observed that the Ca/P ratio of common grasspea genotypes was high. However, when it is thought that this ratio can be tolerated by animals up to 7:1 (Buxton, Fales 1994), it is possible to say that the Ca/P ratios acquired in our study are far below the tolerable value.

Concerning the K/(Ca+Mg) ratio, according to the average data of two years, the highest K/(Ca+Mg) ratio was found in the GAP Mavisi cultivar at 0.918, and the lowest value was revealed in ETH WIR-70 genotype at 0.720 (Table 6). It is reported that the K/(Ca+Mg) ratio in forage crops should be lower than 2.2 (Mayland et al. 1992). Some researchers have stated that the risk of grass tetany increases when this ratio is 2.2 or higher (Elkins et al. 1977, Crawford et al. 1998). In light of this information in the literature, it can be said that the K/(Ca+Mg) ratio determined in the common grasspea genotypes examined in our study did not pose a risk of meadow tetany for animals.

CONCLUSION

According to the research results, it was found that although the common grasspea genotypes grown under semi-arid climatic conditions varied in terms of forage quality parameters, the genotypes produced feed of very good-top quality standards. It was revealed that the majority of the genotypes examined in the study were able to meet the needs of ruminates in terms of P, K, Ca, and Mg. However, it was also revealed that some genotypes were insufficiently rich in some nutrients, particularly Mg. Therefore, depending on the content of nutrients, especially Mg, and chemical properties of the soil, it may be recommended to perform foliar fertilization and improve the physical properties of the soil.

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